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Newfoundland and Labrador Region
Quebec Region

Canadian Science Advisory Secretariat
Science Advisory Report 2011/070

CURRENT STATUS OF NORTHWEST ATLANTIC HARP SEALS, (*Pagophilus groenlandicus*)

Figure 1: Range, migratory pathways and whelping locations of harp seals in the northwest Atlantic.

Context :

Northwest Atlantic harp seals are hunted throughout their range. They are harvested for subsistence purposes by Inuit in Labrador, Arctic Canada and Greenland, and a commercial harvest occurs in the Gulf and at the Front.

Subsistence harvests are currently not regulated while the commercial harvest is regulated by the 2011-2015 Integrated Fisheries Management Plan for Atlantic Seals. In addition, seals are caught incidentally in fishing gear.

Abundance of harp seals is estimated using a population model that incorporates information on removals, annual reproductive rates and periodic estimates of pup production.

Fisheries management has requested that science examine different catch scenarios and determine if they respect the management objective, that is for the next four years (2012-2015) there is an 80% probability that the harp seal population will remain above 70% of its maximum observed size over the long term. They also request Science to provide advice on how a transfer of Gulf quota to the Front would impact on two components of the population.

Canada

SUMMARY

- Northwest Atlantic harp seals are harvested in Canadian and Greenland waters. After averaging approximately 52,000 seals per year between 1983 and 1995, reported Canadian catches increased significantly to a range of 226,000 to 366,000 between 1996 and 2006. Canadian catches have declined significantly since 2007 with a reported catch of 40,370 in 2011. Greenland catches have increased steadily since the mid 1970's reaching a peak of approximately 100,000 in 2000, but have declined to about 80,000 since then. Catches in the Canadian Arctic remain low (<1,000).

- Total removals of harp seals were estimated using reported catches, estimates of bycatch, primarily in the Newfoundland lumpfish fishery, and estimates of seals killed but not recovered (referred to as 'struck and lost') during harvesting in the different regions. From 1996 to 2006, high catches in Canada and Greenland resulted in average annual removals of 483,000. However total removals have declined to less than 250,000 in the past three years, primarily due to the lower catches in the Canadian commercial hunt.

- Catch information dating back to the 18th Century are available for this population. Incorporating these data into a population model results in an estimated pristine population in the early 1800s of about 11 million animals, with wide confidence limits. Assuming environmental conditions are similar today, this provides guidance as to what carrying capacity might be.

- Annual pregnancy rates have been estimated since the 1950s. Estimated pregnancy rates among 4 year olds are low. Estimated pregnancy rates of 5 and 6 year olds increased during the 1970s to a high of 55% and 84%, respectively, and then declined to around 10% for both ages. Pregnancy rates of seals 7 years of age and older remained high until the mid 1980s, but have since declined and become highly variable. In 2011, pregnancy rates of 7+ females were less than 30%.

- The last surveys of the Northwest Atlantic harp seal population were flown in 2008. Combining the estimates from the two photographic surveys at the Front (1,142,985, SE=104,284) with estimates of pup production in the southern Gulf (287,033, SE=27,561), the northern Gulf (172,482, SE=22,287) and another small group at the Front (23,381, SE = 5,492), resulted in a 2008 total pup production estimate of 1,630,300 (SE=110,400, CV=6.8%).

- A model assuming density-dependent population growth, carrying capacity of 12 million and annual reproductive rate data was fitted to the survey data. The model estimated a total population of 8,300,000 (95% CI=7,500,000-8,900,000) in 2008.

- The projected trend in the population between 2008 and 2012 is difficult to predict because of uncertainty associated with reproductive rates and how density dependence is expressed in the model. The 2010 assessment assumed that reproductive rates would remain high and predicted a 2010 population that would lie between 8.61- 9.55 million (95% CI 7.80 to 10.80 million) animals. However, reproductive rates have declined since 2008, and the estimated 2012 population is now estimated to be 7,700,000 (95% CI=6,900,000-8,400,000)

- Science was requested to examine a variety of harvest scenarios to determine their impacts on the population. Harvest levels that will continue to respect the objectives of the

management plan will vary depending on the proportion of young of year (YOY) in the catch; annual harvests of 300,000, 250,000 and 150,000 animals will respect the management objectives if YOY comprise 97%, 90% and 70% of the catch respectively.

- Traditionally, 70% of the harvest has been allocated to the Front and 30% to the Gulf, based upon the relative sizes of the respective populations. Transferring up to 20% of the quota from one component to the other will not result in long-term conservation concerns if it is offset in subsequent years by an equal reduction in the allocation, so that over the term of the management plan, the number of animals removed from each herd does not exceed the total allocation for each component.

- These harvest recommendations are sensitive to the frequency of surveys, assumptions concerning carrying capacity and future changes in reproductive rates, ice conditions and harvests in the unregulated Greenland hunt.

- The current population is estimated to have declined slightly since 2008, nevertheless it is near its highest level since the mid-19th Century. It is recommended that sampling for reproductive samples be increased, particularly in the year of a survey and that the frequency of the pup production surveys be increased to every three years.

INTRODUCTION

The current status of northwest Atlantic harp seal population was re-assessed using data on reproductive rates, removals and estimates of ice-related mortality updated to 2011. Northwest Atlantic harp seals are managed under the 2011-2015 Integrated Fisheries Management Plan for Atlantic Seals. It is considered to be a data-rich population and is managed to maintain an 80 % probability that the population remains above a precautionary reference level (N_{70}) which is defined to be 70 % of the maximum estimated population size.

Science was requested to provide advice on different catch levels and age compositions of the catch and how the transfer of quota from the Gulf to the Front would impact on the two components of the population.

Species Biology

The Northwest Atlantic population of harp seals summers in the Canadian Arctic and Greenland. In the fall, most of these seals migrate southward to the Gulf of St. Lawrence ("Gulf"), or to the area off southern Labrador and northern Newfoundland ("Front") where they give birth in late February or March on medium to thick first year pack ice. Male and female harp seals are similar in size with body length and mass of adults averaging 1.6 m and 130 kg, respectively. Females nurse a single pup for about twelve days, after which adults mate and then disperse. The pup, known as a whitecoat, moults its white fur at approximately three weeks of age after which it is referred to as a beater. Older harp seals form large moulting concentrations on the sea ice off northeastern Newfoundland and in the northern Gulf of St. Lawrence during April and/or May. Following the moult, seals disperse and eventually migrate northward. Small numbers of harp seals may remain in southern waters throughout the summer while a portion of the population remains in the Arctic.

The Hunt

Harp seals have been hunted commercially since the early 18th century. Catches off Newfoundland, and in the Gulf of St. Lawrence, increased significantly after 1820, peaking at over 740,000 seals in 1832. This harvest was directed towards the oil market and was likely a mixture of pups and sexually mature females. Catches ranged from 200,000 to 600,000 throughout the remainder of the 1800s, averaging 360,000 from 1818 to 1913. During the First World War catches declined to less than 100,000 and averaged about 150,000 from 1919 to 1939. Commercial harvesting was greatly reduced during World War Two, but then increased rapidly reaching 450,000 in 1951, averaging about 288,000 seals per year from 1952 to 1971 (Fig. 2).

The first Total Allowable Catch (TAC) was set in 1971 at 245,000. It varied until 1982 when it was set at 186,000 where it remained until 1996. From 1972 to 1982, the average annual catch was approximately 165,000 seals. Prior to 1983, the large-vessel take of white-coated pups on the whelping patch accounted for the majority of the harvest. A ban on the importation of whitecoat pelts implemented by the European Economic Community in 1983 severely reduced the market, ending the traditional large-vessel hunt. From 1983 to 1995 catches remained low, averaging ~50,000 per year. The quota was increased in the mid 1990s and an average of 262,000 seals was taken annually between 1996 and 2002. From 2003-06, a multiyear quota was set at 975,000 seals (average 325,000 per year) with a maximum of 350,000 in any two years and the remainder in the third. A total of 985,312 animals were taken over the three years of this plan (Table 1). The multiyear quota system was not renewed in 2006 when an annual quota of 335,000 was set. The quota was subsequently reduced in 2007 to 270,000 due to poor ice conditions and to ensure the population was maintained above the Precautionary Reference Level. It was increased slightly in 2008 to 275,000 and again in 2009 to 280,000. The 2010 TAC was increased significantly to 330,000. Although the quota was exceeded in 2006, catches in 2007, 2008 were ~80% of the TAC and only ~ 27% in 2009. A further reduction in effort resulted in a 2010 catch of 69,101 which is 21% of the TAC. Young of the year (YOY) seals that have moulted their whitecoat ('beaters') make up over 97% of the harvest since 2000. In 2011, the total catch was 40,370, which is only 10% of the TAC. YOY comprised over 99% of the harvest in 2010 and 2011.

Table 1: Canadian commercial (plus TAC) and Greenland catches of harp seals (,000s), 2001-2011.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Canada											
TAC	275	275	350[1]	350[1]	319.5	335	270	275	280	330	400
Catch	226.5	312.4	289.5	366.0	323.8	354.9	224.7	217.8	76.7	69.1	40.4
Greenland											
Catch	85.4	66.7	66.1	70.6	91.7	92.2	82.8	80.6	71	N/A	N/A

[1] Maximum annual catch under the three year management plan, totalling 975.

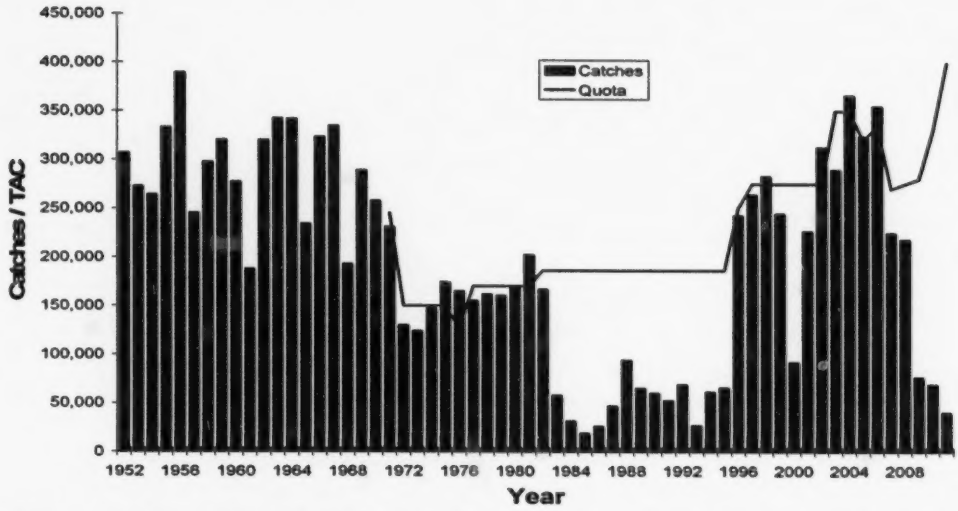

Figure 2. Total Allowable catches (line) and Canadian reported catches (bars) of northwest Atlantic harp seals and quotas, 1952 to 2011.

Harp seals are currently hunted by land-based sealers in both the Gulf and Front areas during the winter. Current regulations do not allow the hunting of adults in the whelping patch, the harvest of whitecoats, or the use of vessels greater than 20 m in length.

Prior to 1980, catches of Northwest Atlantic harp seals in Greenland were consistently less than 20,000 animals (Fig 3). Since 1980, Greenland catches increased relatively steadily to a peak of over 100,000 in 2000. Since then, catches have ranged from 62,000 – 92,000, averaging just under 80,000 seals per year. Catches in the Canadian Arctic are not well documented, but appear to be low with likely fewer than 1,000 harp seals taken annually in recent years (Fig 3).

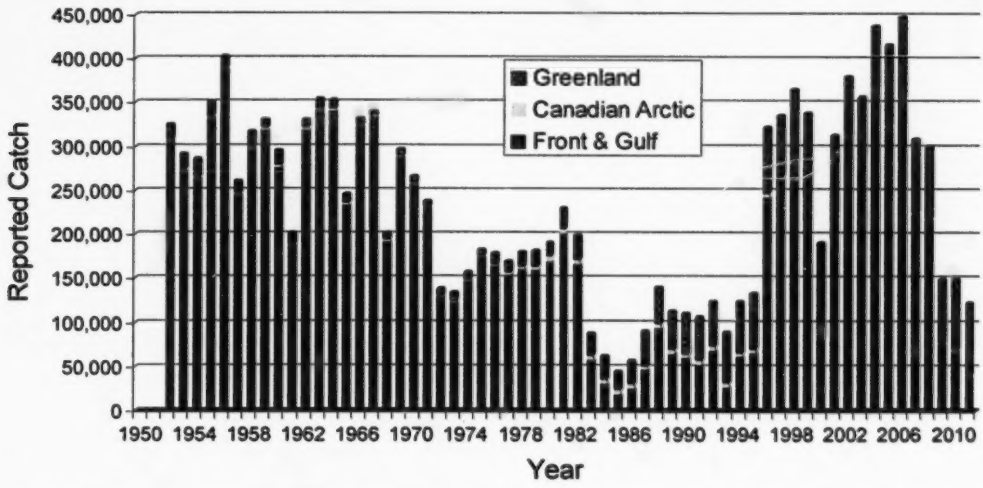

Figure 3: Reported commercial and subsistence catches of harp seals in the northwest Atlantic 1952-2011. Totals do not include seals killed but not landed, or those killed as bycatch in commercial fisheries. Greenland harvests since 2009 are assumed.

Other Sources of Human-Induced Mortality

In addition to reported catches, some seals are killed, but not recovered or reported (referred to as 'struck and lost'). Loss rates of young seals during the large vessel, whitecoat hunt (prior to 1983) are considered to be low (~1%). Estimates of the additional mortality caused by struck and lost for YOY seals which make up the majority of the current harvest in Canada appear to be 5 % or less (assumed 5%) while losses of older seals are higher (assumed to be 50 % of those killed). This higher figure is also applied to catches in the Canadian Arctic and Greenland when estimating total removals (Fig. 4).

Harp seals are also taken as bycatch in fishing gear. The Newfoundland lumpfish fishery is thought to be responsible for the largest bycatch mortality of seals. Seals are taken in other fisheries although the numbers caught have not been estimated. Estimated numbers of seals taken annually as bycatch in the lumpfish fishery were generally below 1,000 seals prior to 1976; however, by the late 1980s and early 1990s catches had increased to over 10,000 in some years (Fig. 4). Peak catch levels occurred from 1992-96 with an average take of 29,431 seals annually. Although catches have been variable in recent years, less than 5,500 seals were taken in 2003. A small number of harp seals (<500/yr) are taken in fishing gear in the northeastern United States.

To estimate total removals, reported catches in Canada and Greenland are combined with estimates of bycatches and struck and lost. Between 1952 and 1971, removals averaged 388,000 seals, primarily due to commercial catches in southern Canada. Removals fell with the imposition of Canadian quotas in 1971, averaging just over 226,000 from 1972 to 1982. The decline of Canadian catches between 1983 and 1995 resulted in fewer annual removals (average 176,000) although the contribution of struck and lost to the total increased due to the higher level assumed for the Greenland hunt. Between 1996 and 2004, higher catches in Canada and Greenland resulted in average annual removals of 468,500. Since 2007, the level of total removals has declined due to lower catches in the Canadian commercial hunt. Total removals were estimated to be less than 250,000 since 2009 (Fig. 4). Young of the year have declined from approximately 65 % of the total removals in the early 2000s to 31% in 2011 due to the increased importance of the Greenland hunt.

ASSESSMENT

Resource Status

The number of harp seal pups born in a year is estimated periodically from aerial surveys conducted in the spring, when the seals have hauled out onto the ice to have their pups. Estimates of total population are based on a population model that incorporates these estimates of pup production with information on reproductive rates (the proportion pregnant each year), catches in Canada and Greenland, by-catch and struck and lost as well as information on unusual pup mortality due to poor ice conditions. At the 2010 assessment it was concluded that density-dependent factors were affecting the dynamics of this population; consequently the model used to describe the population trajectory was modified to include density-dependent changes in survival among YOY animals.

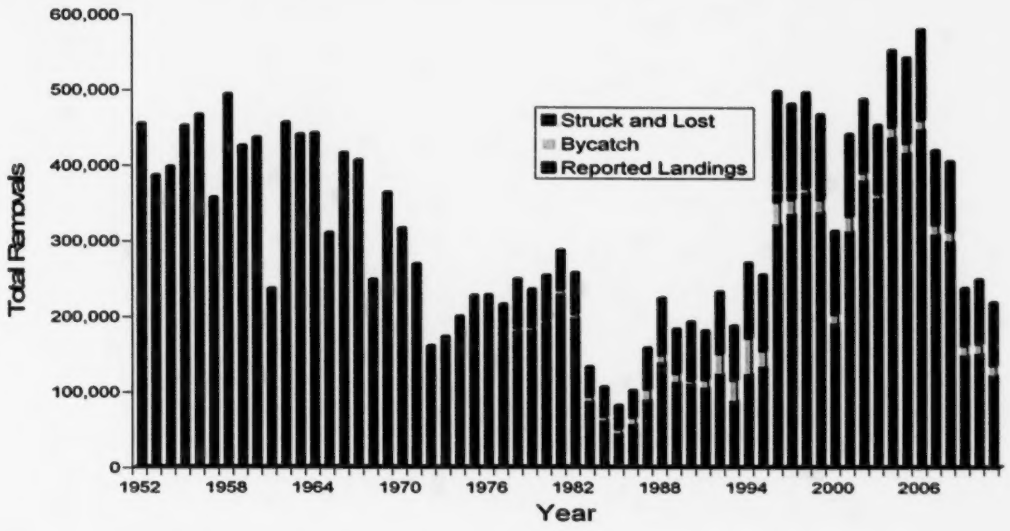

Figure 4. Total removals of Northwest Atlantic harp seals, 1952 to 2011.

Pup Production

In the past, pup production has been estimated from catch data, mark-recapture experiments, and aerial surveys. Estimates for the mid to late 1970's ranged from approximately 250,000 to 500,000. The Royal Commission on Seals and Sealing in Canada concluded that pup production in 1978 was about 300,000-350,000 and the total population was about 1.5-1.75 million. Aerial surveys, off the Front and in the Gulf of St. Lawrence, resulted in pup production estimates of 580,000 (± 78,000) pups in 1990, 703,000 (± 125,000) in 1994, 998,000 (± 200,000) in 1999 and 991,400 (± 114,100) in 2004 (Fig. 5). Total pup production increased throughout the 1980s and 1990s (Fig. 5), but appeared to have slowed as the 2004 estimate was not significantly different from the 1999 estimate. This stabilization of pup production was thought to be due, in part, to the increased catches of young seals since 1996 and was consistent with previous model predictions.

Photographic and visual aerial surveys were flown off Newfoundland and in the Gulf of St. Lawrence during March 2008 to estimate current pup production. Surveys of five whelping concentrations were conducted between 1 and 16 March resulting in estimates of pup production of 287,000 (SE=27,600, CV 9.6 %) in the Southern Gulf and 176,800 (SE=22,800, CV=12.9 %) in the Northern Gulf. A large concentration at the Front was estimated to contain 1,142,985 (SE=104,284, CV=9%) animals. A small concentration at the Front was estimated to contain 23,400 (SE=5,500, CV=23.5 %) pups. Combining estimates from the different concentrations resulted in an estimate of total pup production of 1,630,300 (SE=110,400, CV=6.8) for Northwest Atlantic harp seals in 2008.

Reproductive Rates

Pregnancy rates and mean age of maturity have varied considerably since the 1950s. In the mid 1950s the average age at which harp seals matured was 5.8 years whereas from the late 1970s through the mid 1980s they matured a year younger (~4.5 years of age). By the mid 1990s, the mean age of maturity increased to 5.7 years, where it remained for several years. With the

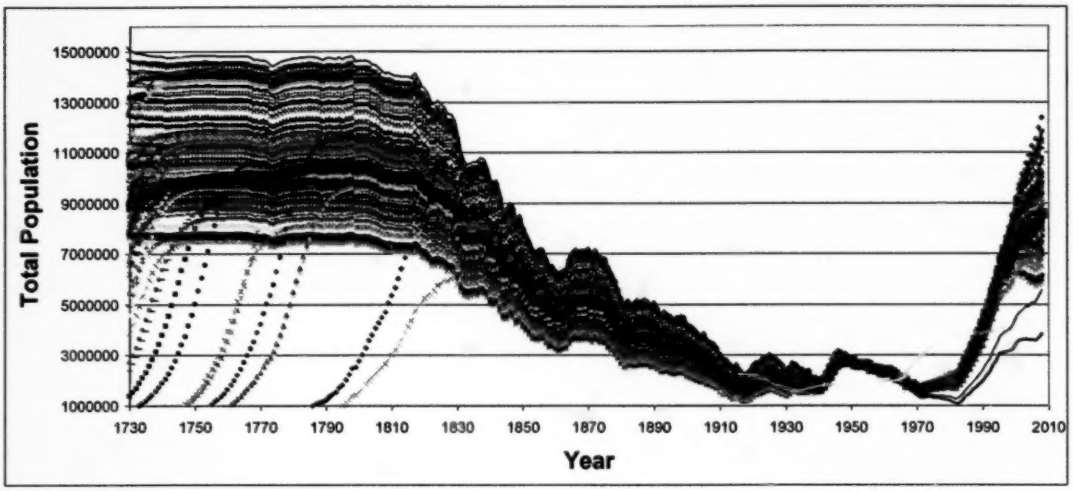

Figure 6. Estimated changes in abundance of Northwest Atlantic harp seals (1730-2010) from different model fits to the historical catch data. The mean abundance is shown by the thick red line (Hammill et al. 2011).

Assuming that K= 12 million animals, and incorporating annual reproductive rates resulted in a pup production in 1952 of 500,000 (Fig.7). Pup production declined throughout the 1960s, reaching a minimum 1971, and then increasing to 1,600,000 in 2008. Estimated pup production declined to 600,000 in 2011, but could increase to 1,200,000 in 2012, depending upon the assumed reproductive rate. The total population size in 1952 was 2,300,000 declining to a minimum in 1971, then increasing to 8,300,000 in 2008. The 2008 estimate is also N_{Max}. The population has declined since then and the estimated 2012 population is 7,700,000 (Fig. 7).

Catch options

Science was requested to provide advice on whether the following catch scenarios respect the current management plan over the next four years. The scenarios were:

A) 400,000 for each year with 10% adults/ 90% beaters;
B) 400,000 for each year with 30% adults/ 70% beaters;
C) 500,000 for each year with 10% adults/ 90% beaters; and
D) 500,000 for each year with 30% adults/ 70% beaters.

Science was also asked to provide advice on the impact of a transfer from Gulf Quota to the Front on the population given the following scenarios:
A) one year of Gulf sealers taking approximately 50K, and 100K seals from the Front quota;
B) two years of Gulf Sealers taking approximately 50K, and 100K seals from the Front quota;
C) five years of Gulf Sealers taking approximately 50K, and 100K seals from the Front quota.

For the projections, by-catch and removals in Arctic Canada were assumed to be the same as in 2009. As in the past, the Greenland harvest was assumed to vary between 70,000 and 100,000 with an average of 85,000. The Canadian harvest composition varied with the scenarios examined. Over the last decade there has been an increase in the frequency of years with poor ice conditions which likely resulted in increased mortality among young of the

year. In previous years, the impacts of different harvest levels were evaluated assuming that YOY mortality had increased as a random variable with an average of 12% per year. In this assessment, we assumed a uniform distribution with values assigned over the last five years used as values for M. Reproductive rates have declined markedly since 2008. However, the future direction of reproductive rates is not known, therefore model projections into the future selected reproductive values from an array of observed values over the last five years. Reproductive values had an equal probability of being selected.

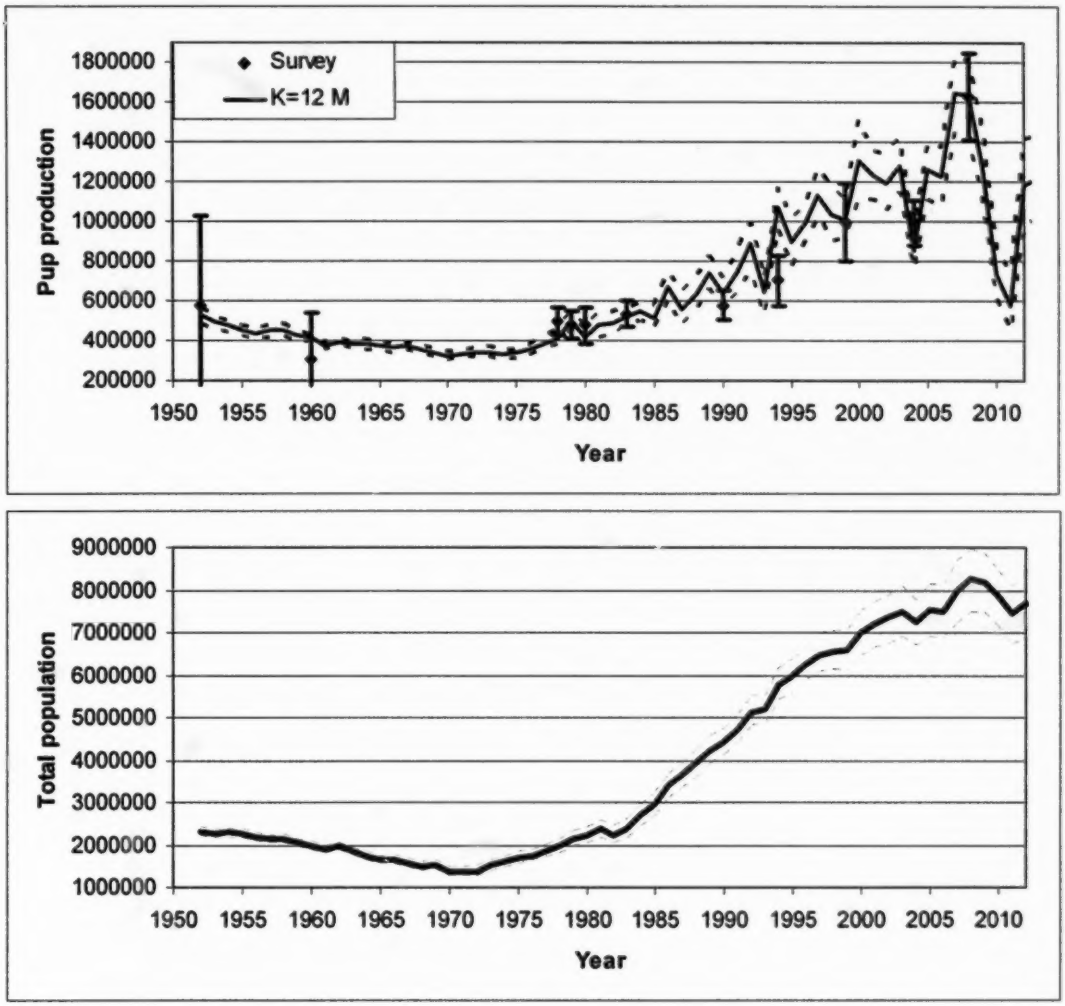

Figure 7: Aerial surveys (±95% CI) and model estimates of pup production (top). Estimated total population for Northwest Atlantic harp seals for 1952-2012 assuming K= 12 million (Bottom). The model was fitted to the data assuming K=12 million.

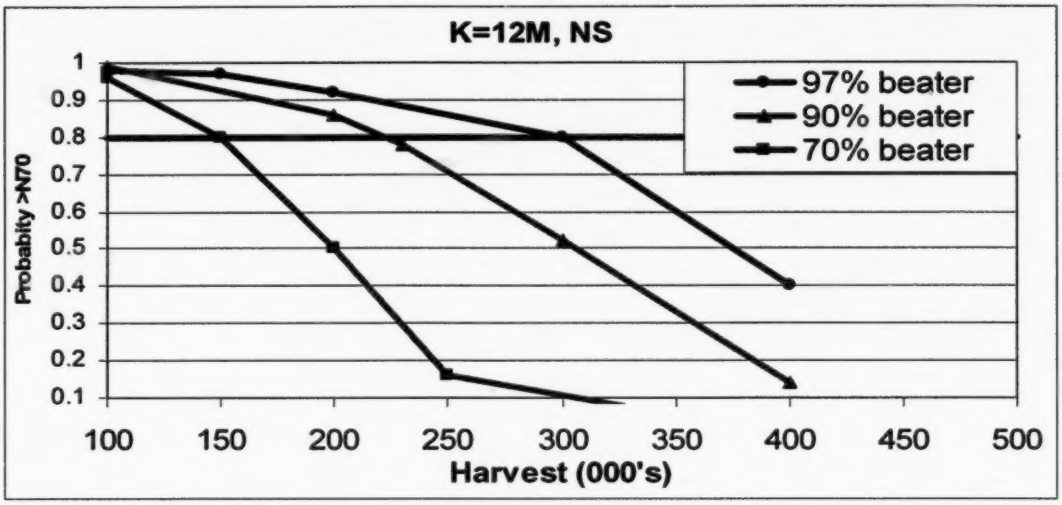

Figure 8. Probability of the population remaining above N70 under different compositions of the harvest. The management objective is to maintain an 80% probability that the population above N70.

The level of harvest that would respect the management plan will vary with the age composition of the harvest (Fig. 8). Assuming that YOY comprise 97% of the catch, annual harvests of up to 300,000 animals over the next three years will respect the management plan. If the proportion of YOY decreases to 90% then a harvest of 230,000 would continue to respect the management objective, whereas if the harvest composition declined to 70% YOY, a maximum harvest would be 150,000 animals.

Previous assessments have shown that a carryover of up to 20% would still respect the management objectives, if the overall number of animals removed over the life of the management period remained unchanged. Therefore, years when the number of animals removed was higher, would be accompanied by a reduction in allowable catch of an equal amount in subsequent years. Currently the Front accounts for an average of 70% of the harp seal pup production, while approximately 30% occur in the Gulf. Allocations to the Front and Gulf fleets reflect these percentages. Poor ice conditions observed in recent years, have prevented the Gulf fleet from obtaining their allocation and industry has asked for permission to take their quota at the Front. If the total quota is set at the highest level that is consistent with the management objective, allowing the Gulf fleet access to the Front, by increasing the allocation from the Front by up to 20% will not result in long-term conservation concerns for the Front herd. However, this must be offset in subsequent years by an equal reduction in the allocation, so that over the term of the management plan, the number of animals removed from each herd does not exceed the total Front allocation over the life of the management plan.

Sources of Uncertainty

Pup production estimates are a critical component of the harp seal population model. The 2008 estimate was significantly higher than the 2004 estimate. This high estimate appears to be largely due to high reproductive rates observed in 2008. Since then, model estimated pup production has declined and in 2010 and 2011 was considerably lower than in 2008. Analysis of the reproductive data indicates that reproductive rates have declined substantially since 2008.The general downward trend and high variability in the annual reproductive data indicates

that density-dependent factors are likely affecting the dynamics of this population and that annual data are required by the population model to estimate pup production, particularly in years when surveys are flown. With survey intervals of 4-5 years it is not possible to determine environmental carrying capacity for this population (K), or how rapidly the population is approaching K. Reconstruction of historic population size provides an indication of the pre-exploitation population size and an indication of potential K, but it assumes that environmental conditions today are similar to those observed in the 18th century. Uncertainty in K and future trends in reproductive rates and population response to changing environmental conditions (e.g. ice conditions) limits our ability to predict harvest impacts. Harp seals are pelagic and undertake seasonal migrations between an Arctic ecosystem and a north Atlantic ecosystem. Availability of food resources and carrying capacity in these two systems are not known and likely vary.

Additional uncertainty is associated with the catch data and factors applied to correct the catch data for animals that are killed, but not recovered (struck and loss). If these correction factors are too high, the population model will produce estimates of adult mortality that are too low although the estimates of total population should not change significantly.

Removals have been estimated since 1952. However, the accuracy of reported catches, particularly the subsistence catches in the Canadian Arctic and Greenland, is unknown. Also, there is uncertainty about the ages of seals killed in the various catches and the estimates of by-catch in Canadian fisheries. Additional catches likely occur in other fisheries and are assumed to be small, but these have not been quantified. The Greenland harvest has varied greatly over the last decade. Although The Greenland catch has declined since 2006, at an average of around 80,000 per year, it's impact on population growth is much greater than the Canadian commercial catch (Table 1). The Greenland harvest is not limited by quota; therefore when estimating the impact of future catches, we entered the Greenland harvest into the model as a uniform function with a range of 70,000 to 100,000. Also, there is considerable uncertainty in the age structure, and level of struck and lost that occurs in this harvest. Given the level of harvest and the higher proportion of older animals taken, the Greenland harvest has an important impact on the population dynamics of northwest Atlantic harp seals. Also, each of the projections were modelled assuming that the level of subsistence catch in the Canadian Arctic, by-catch in fishing gear and the age structure of the harvest remained unchanged. Current estimates of these catches are not available.

The current assessment model estimates natural mortality rates to fit observed data on reproductive rates and total removals to survey estimates of pup production. The model assumes that mortality does not change over the projection period and is constant for seals one year of age and older. However, natural mortality is likely to have changed over the time and with age. Some of this change may be accounted for by assuming density dependent changes in pup mortality, but independent estimates of mortality are needed to verify model predictions and to improve information concerning the dynamics of this population.

Climate change may result in reduced availability or thickness of suitable ice in the areas traditionally used by harp seals to give birth and nurse their pups. Also, some climate models predict an increased frequency of storms during the nursing period. These climatic changes may result in increased mortality of pups or changes in whelping locations which can affect our ability to provide accurate predictions of future abundance.

CONCLUSIONS

The Northwest Atlantic harp seal population has increased fourfold since the 1970s. A general decline in age-specific reproductive rates, mean age of maturity and individual growth rates suggest that density dependent factors are affecting the dynamics of this population. The reduction in reproductive rates and increase in YOY mortality related to poor ice conditions in Atlantic Canada, particularly in the Gulf of St. Lawrence have contributed to a slight population decline in recent years. The available data do not allow us to adequately describe the density-dependent relationships affecting the dynamics of this population. Currently surveys are flown every 4-5 years. Additional pup abundance estimates, including reducing the interval between surveys to 3 years, as well as annual age-specific reproduction data are needed to improve our understanding of the dynamics of this population. Because of the importance of understanding changes in reproductive rates, it is important that adequate samples be collected to determine annual late term pregnancy rates, particularly in survey years.

OTHER CONSIDERATIONS

Subsistence harvests in Greenland and Arctic Canada are currently not regulated. Harvest age structure and levels in these areas, particularly in Greenland, can have a significant impact on the population dynamics of this population.

SOURCES OF INFORMATION

This Science Advisory Report has resulted from a Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, National Advisory Meeting of October 17-21, 2011 on National Marine Mammal Peer Review Committee Meeting (NMMPRC). Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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